133 Audiometry

ANNE Z. SAUNDERS, ANDREA VALLEN STEIN, and NANCY LITE SHUSTER

Definition

Audiometry consists of tests of function of the hearing mechanism. This includes tests of mechanical sound transmission (middle ear function), neural sound transmission (cochlear function), and speech discrimination ability (central integration). A complete evaluation of a patient's hearing must be done by trained personnel using instruments designed specifically for this purpose.

Pure tones (single frequencies) are used to test air and bone conduction. These and speech testing are done with an audiometer. The *audiometer* is an electric instrument consisting of a pure tone generator, a bone conduction oscillator for measuring cochlear function, an attenuator for varying loudness, a microphone for speech testing, and earphones for air conduction testing.

Other tests include *impedance audiometry*, which measures the mobility and air pressure of the middle ear system and middle ear (stapedial) reflexes, and *auditory brainstem response* (ABR), which measures neural transmission time from the cochlea through the brainstem.

Technique

Pure tone audiometric air conduction testing is performed by presenting a pure tone to the ear through an earphone and measuring the lowest intensity in decibels (dB) at which this tone is perceived 50% of the time. This measurement is called *threshold*. The testing procedure is repeated at specific frequencies from 250 to 8000 hertz (Hz, or cycles per second) for each ear, and the thresholds are recorded on a graph called an audiogram. *Bone conduction testing* is done by placing an oscillator on the mastoid process and measuring threshold at the same frequencies. Masking noise is sometimes used in the nontest ear to prevent its participation in the test.

The audiogram is a graph depicting hearing thresholds in decibels on the ordinate and frequency in hertz on the abscissa. The symbols in Figure 133.1 are used to plot thresholds for pure-tone air and bone conduction testing. The zero level on the audiogram is an arbitrary sound pressure level which indicates ideal normal hearing in young adults.

Speech testing is the measurement of a patient's ability to hear and understand speech. The speech reception threshold (SRT) is the lowest decibel level at which a patient can correctly repeat 50% of test words. The speech threshold should be within ± 10 dB of the pure tone average at frequencies of 500, 1000, and 2000 Hz. The speech discrimination score is obtained using phonetically balanced, one-syllable words usually presented at 25 to 40 dB above the hearing threshold obtained from the pure-tone audiogram.

Speech discrimination is usually good in purely conductive hearing losses when the presentation level is loud enough. Speech discrimination scores are variable in sensorineural losses. Poor speech discrimination (75% or less) in the presence of little loss for pure tones raises the index of suspicion for retrocochlear disease.

For *impedance audiometry*, a hermetic seal is obtained by inserting a probe tip in the external ear canal. The pressure in the enclosed cavity is varied from +200 to −200 mm H_2O and the change in sound pressure level of a probe tone is graphed. This shows the movement of the middle ear system as pressure is varied. Figure 133.2 shows types of tympanograms for different conditions of the middle ear.

The contraction of the stapedius muscle in response to a loud sound can be measured on the impedance bridge. In the normal ear, these reflex thresholds should be seen

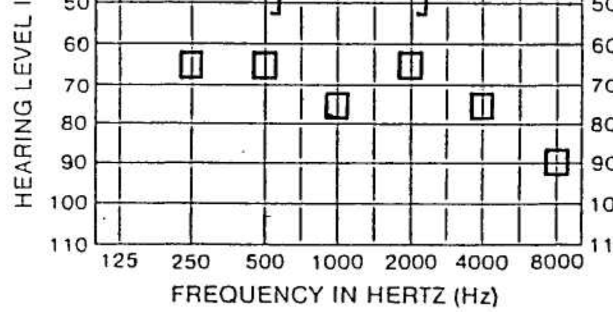
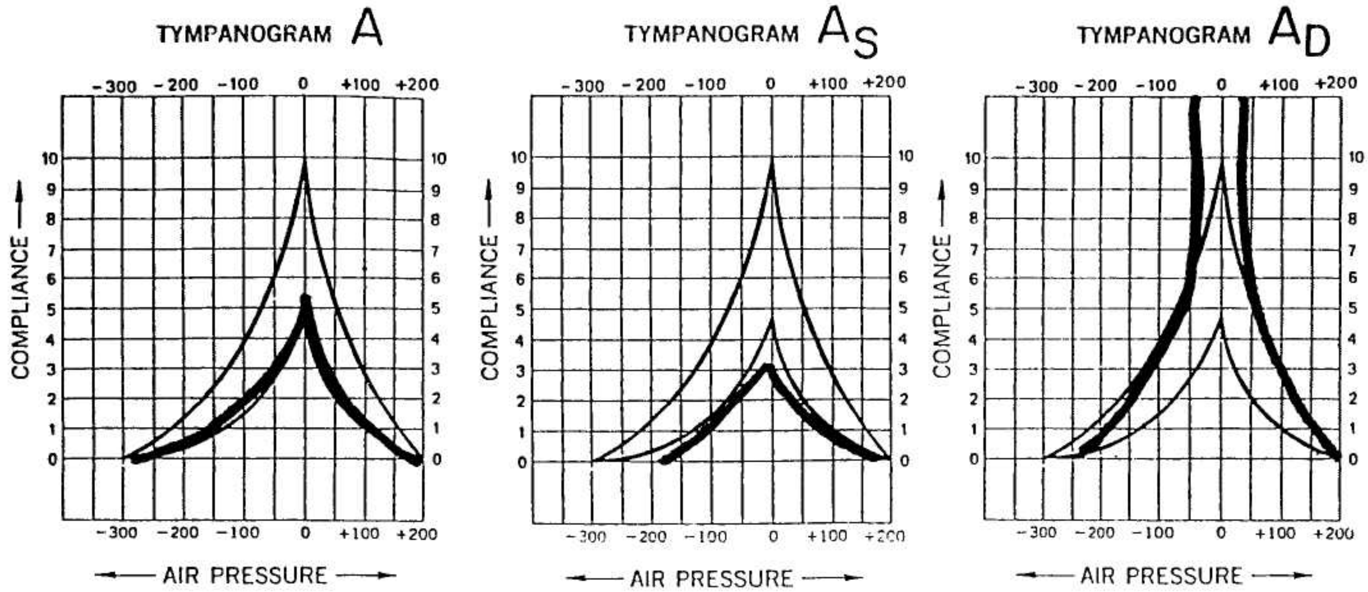


Figure 133.1
Audiometry results. The right ear shows thresholds that are within normal limits for air and bone conduction. The left ear shows a mixed hearing loss. The bone conduction thresholds show a sensorineural hearing loss. Air conduction thresholds show an additional loss. This difference between air and bone conduction is known as an air-bone gap and signifies a conductive hearing loss. KEY: < Right ear, bone conduction; O Right ear, air conduction;] Left ear, bone conduction; □ Left ear, air conduction.



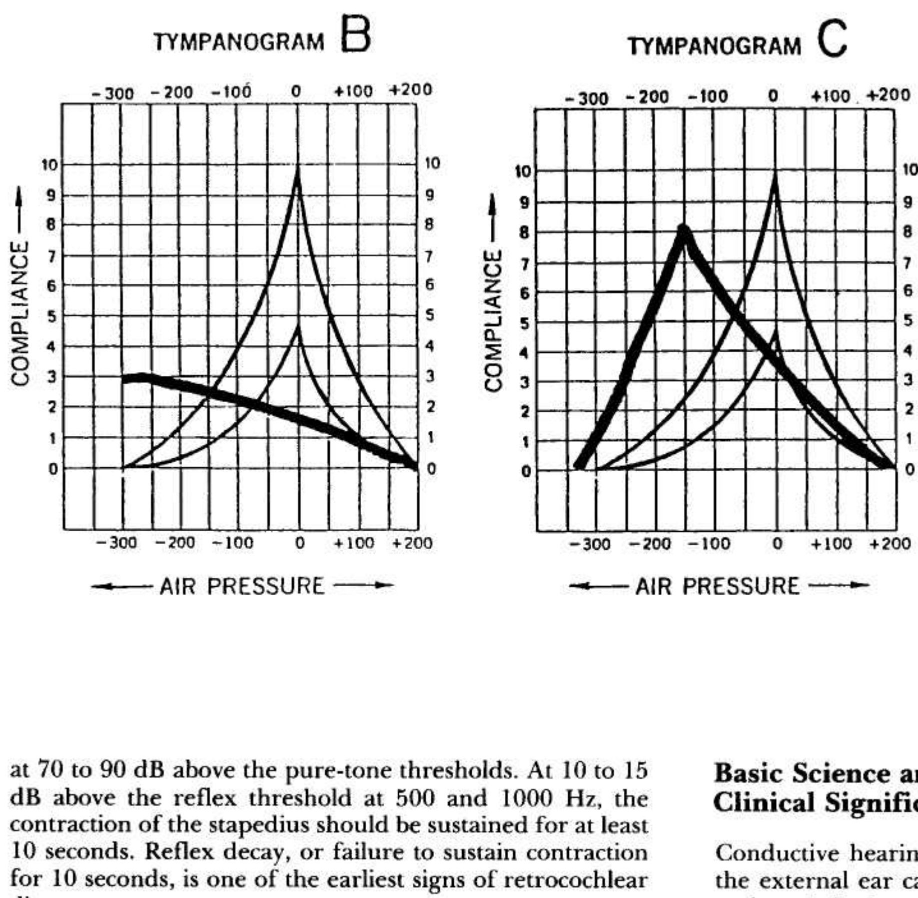


Figure 133.2
Five common tympanograms. The lighter lines with a peak at 0 enclose a space that represents the range of normal middle ear system mobility and pressure.

Type A: Normal tympanic membrane (TM) mobility and normal middle ear (ME) pressure.

Type As: Reduced TM mobility and normal ME pressure; consistent with presence of otosclerosis. Represents stiff ME system.

Type AD: Hypermobility of TM and normal ME pressure; consistent with flaccid TM or disarticulation of ossicular chain.

Type B: Reduced TM mobility; consistent with presence of fluid in the middle ear space.

Type C: Normal TM mobility and negative ME pressure; consistent with eustachian tube dysfunction.

at 70 to 90 dB above the pure-tone thresholds. At 10 to 15 dB above the reflex threshold at 500 and 1000 Hz, the contraction of the stapedius should be sustained for at least 10 seconds. Reflex decay, or failure to sustain contraction for 10 seconds, is one of the earliest signs of retrocochlear disease.

For *auditory brainstem response (ABR) audiometry,* electrodes are placed on the patient's vertex, earlobes, and forehead. Clicks are delivered through earphones, and a computer sums the time-locked responses (potentials) for the first 10 msec after sound stimulation. From these responses, a display of five characteristic waves is generated at predictable latencies. This response must be reliably repeatable for an evaluation to be made. Figure 133.3 illustrates a normal ABR response, a response from an ear with an acoustic neuroma, and an ear with no identifiable response.

Basic Science and Clinical Significance

Conductive hearing loss may be caused by obstruction of the external ear canal (e.g., wax) or middle ear problems such as infection, tumor, fixation of the ossicles (otosclerosis), and congenital diseases. Many conductive losses can be managed medically or surgically.

Sensorineural hearing loss (cochlear or eighth nerve damage) may be caused by conditions such as maternal rubella, mumps, meningitis, noise trauma, otologic effects of aging (presbycusis), ototoxic drugs, trauma, Ménière's disease, hyperlipidemia, hereditary syndromes, demyelinating diseases, and tumors affecting the eighth nerve. A patient with sensorineural hearing loss is usually a candidate for a hearing aid.

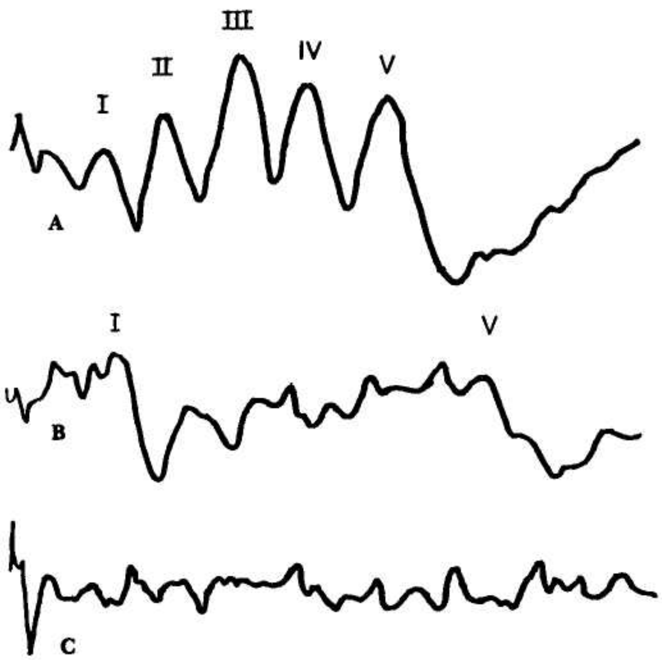


Figure 133.3
Three types of ABR responses. *(A)* Normal response showing five waves. Wave I represents the auditory nerve, Wave II the cochlear nuclei, Wave III the superior olive, Wave IV the lateral lemniscus, and Wave V the inferior colliculus. The longest latency acceptable for a normal Wave V is 5.9 msec. *(B)* Abnormal ABR response showing a delayed Wave V. This patient was diagnosed as having an acoustic neuroma. *(C)* Abnormal ABR showing no identifiable waveforms. This helped to confirm the diagnosis of profound hearing loss secondary to meningitis at age 4 months.

Carefully performed audiometry can make an invaluable contribution to diagnosis and management of patients with ear problems. Figures 133.1, 133.2, and 133.3 illustrate the tests presented above.

References

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